

## Assignment 2 COL786 (2020CH70182)

Google Drive link:

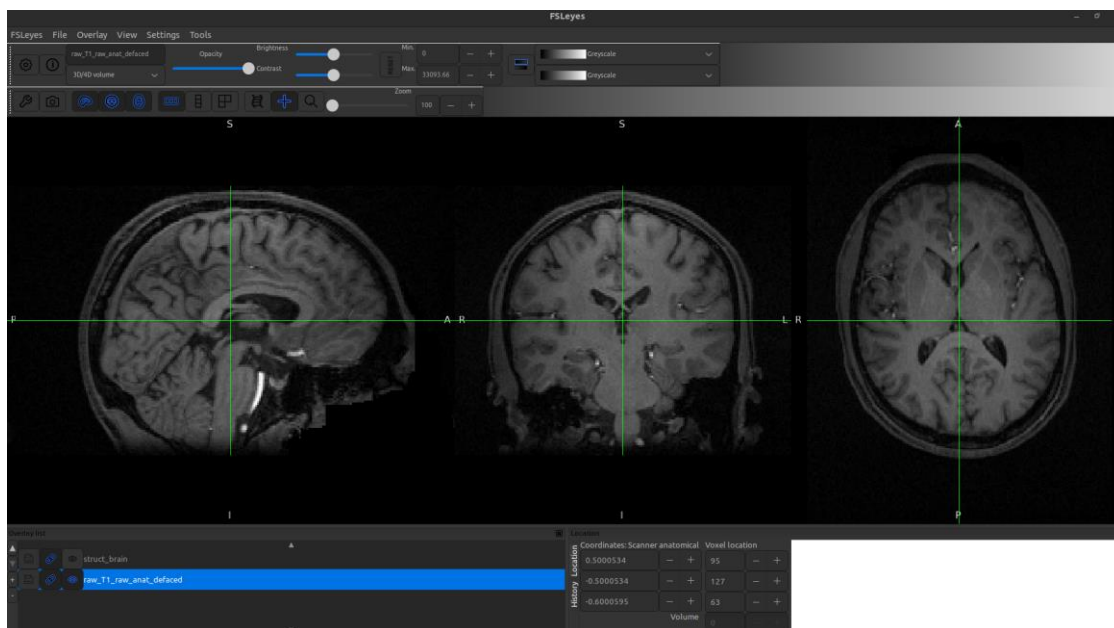
<https://drive.google.com/drive/folders/1O6NAWMaETkOzMdFN2cGG1LR3vzScx3aG?usp=sharing>

### Part1

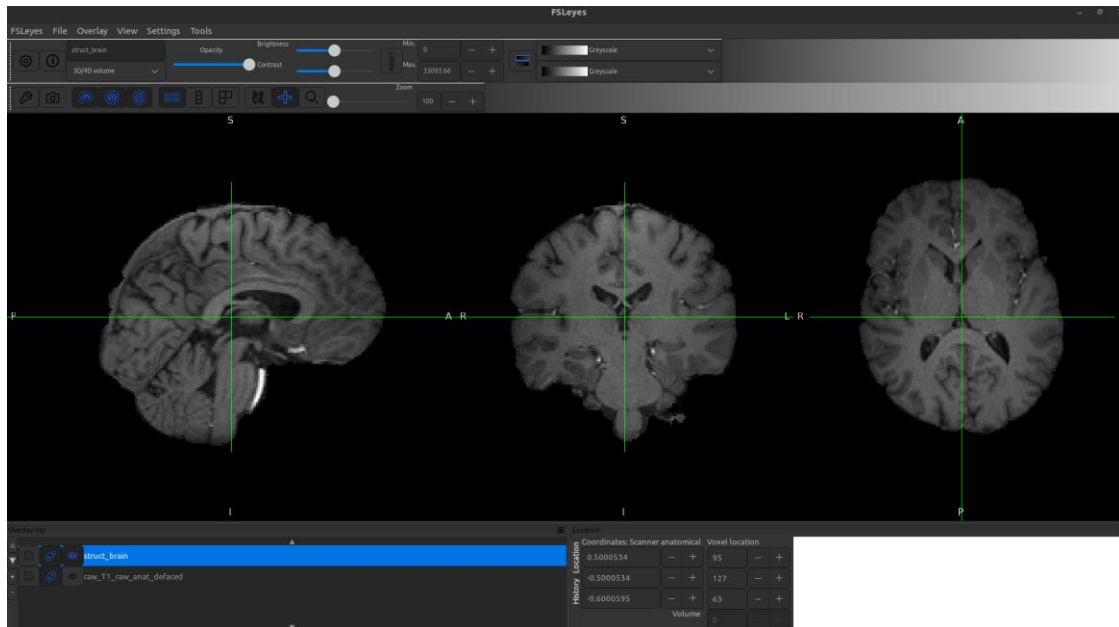
Pre-processing of Structural MRI

Structural MRI → Brain Extraction → Linear Registration to Standard MNI Template

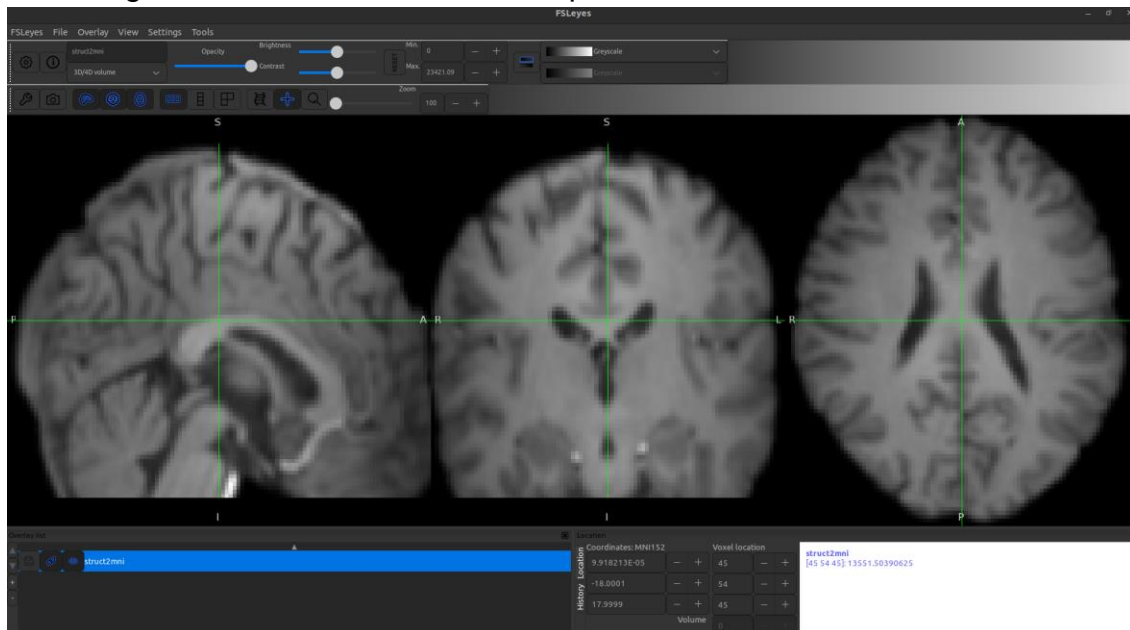
Before brain extraction:



After Brain extraction:



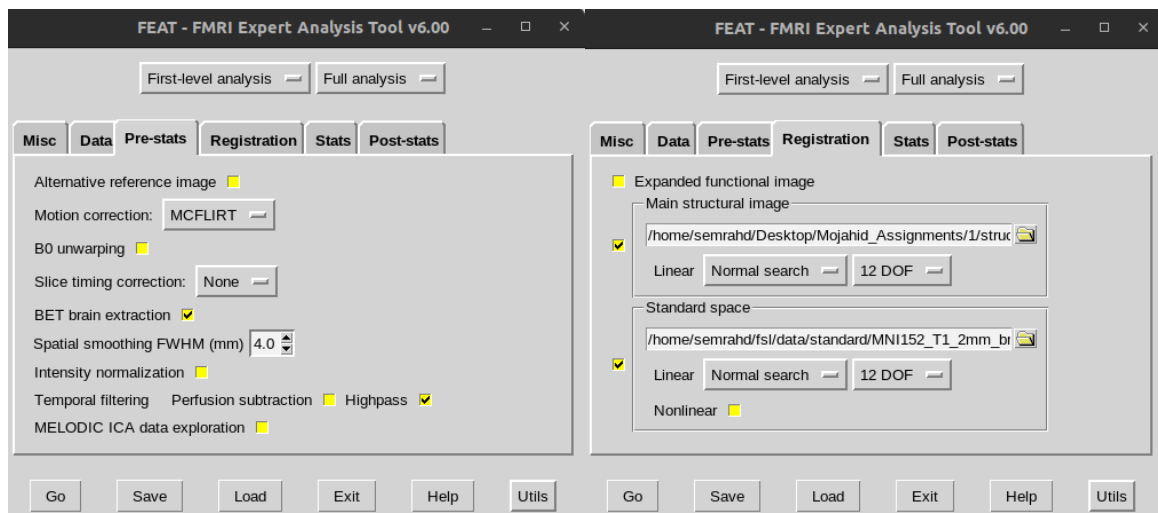
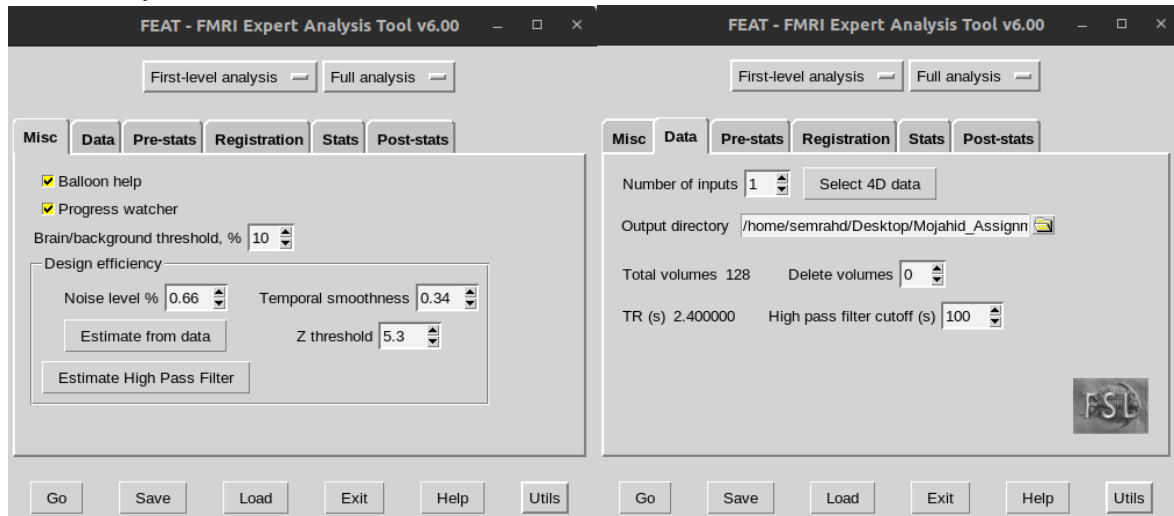
After Registration to Standard MNI Template

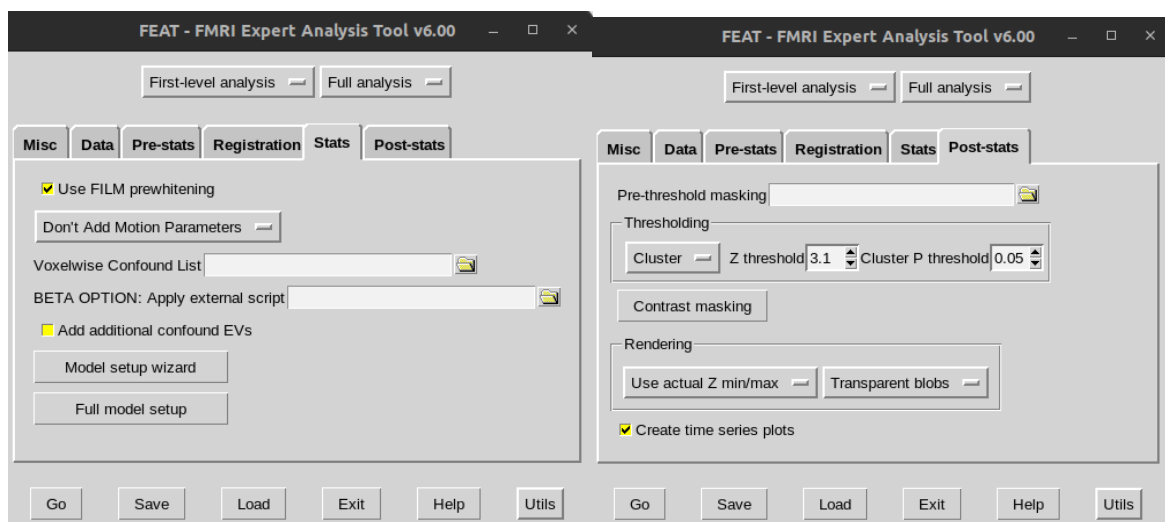


## Pre-processing of Functional MRI

Functional MRI → Brain Extraction → Motion Correction → Spatial Smoothing → Temporal Filtering → Registration to Structural MRI

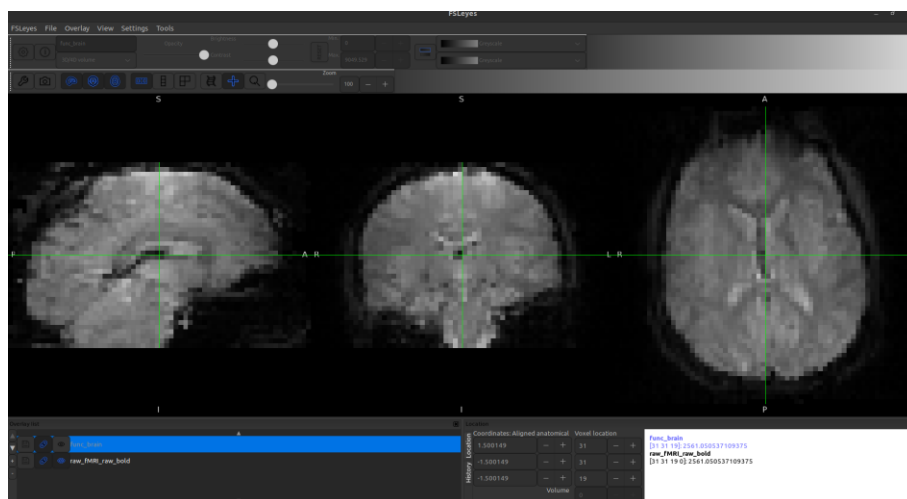
## Feat analysis GUI



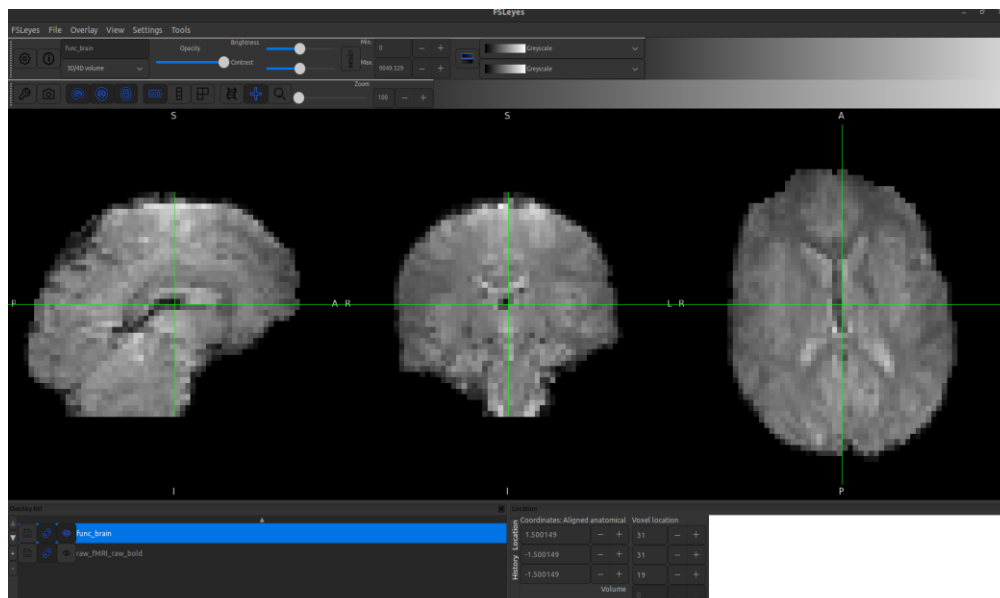


## Brain extraction from functional MRI

Before:

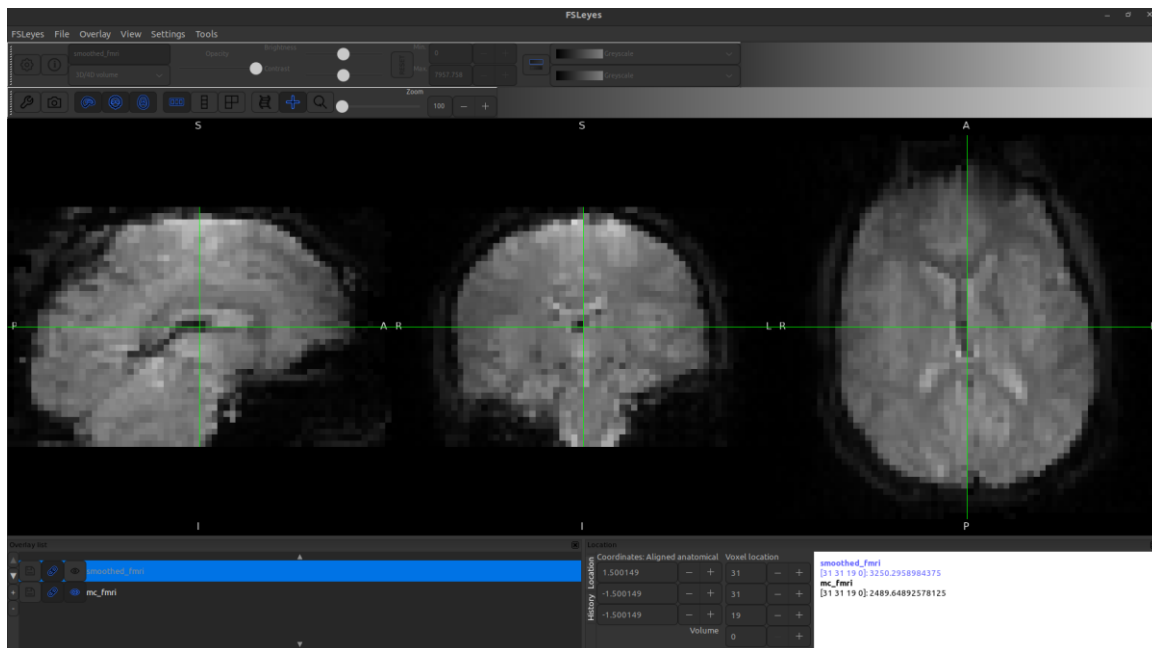


After Brain Extraction:

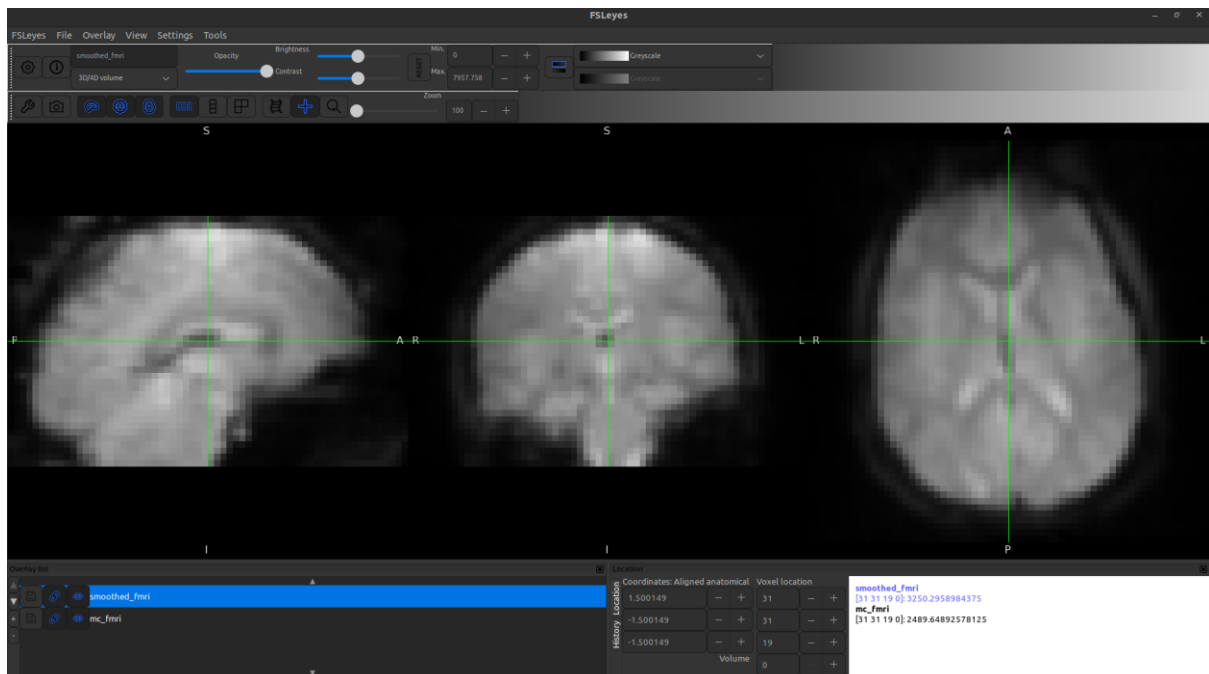


## Spatial Smoothing

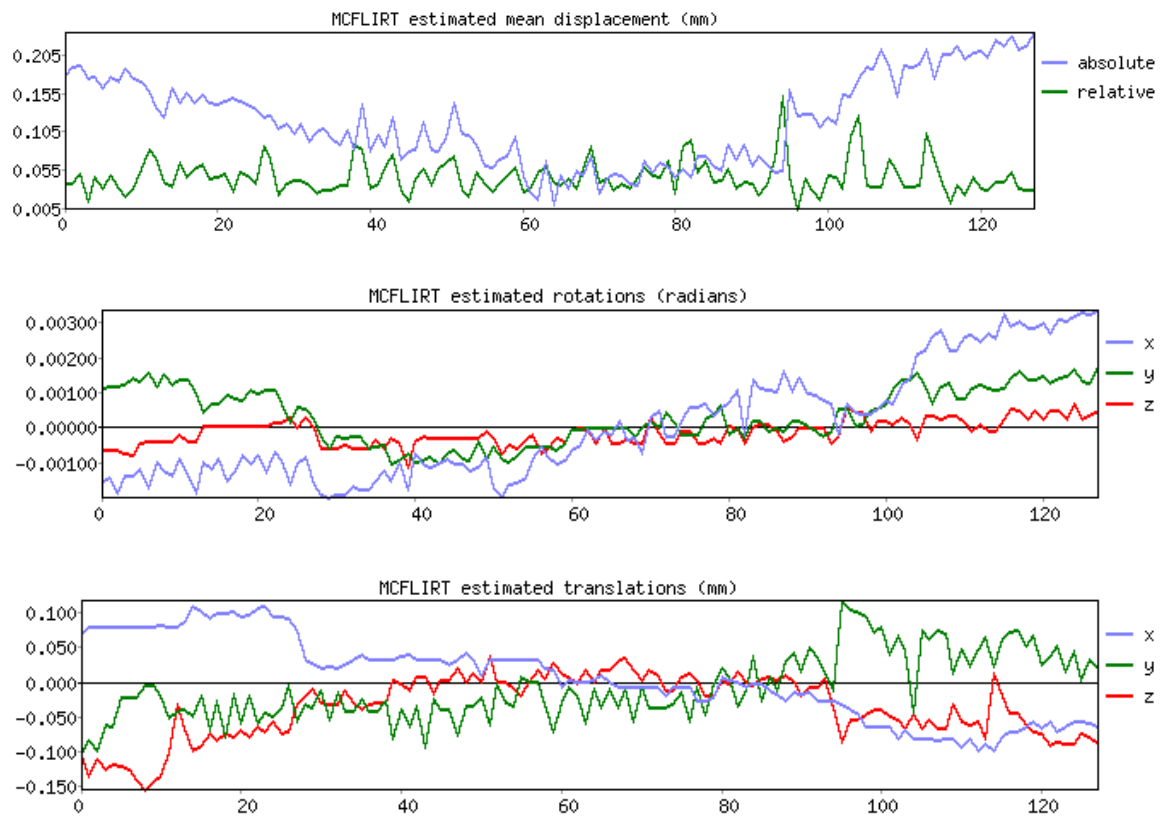
Before:



## After:

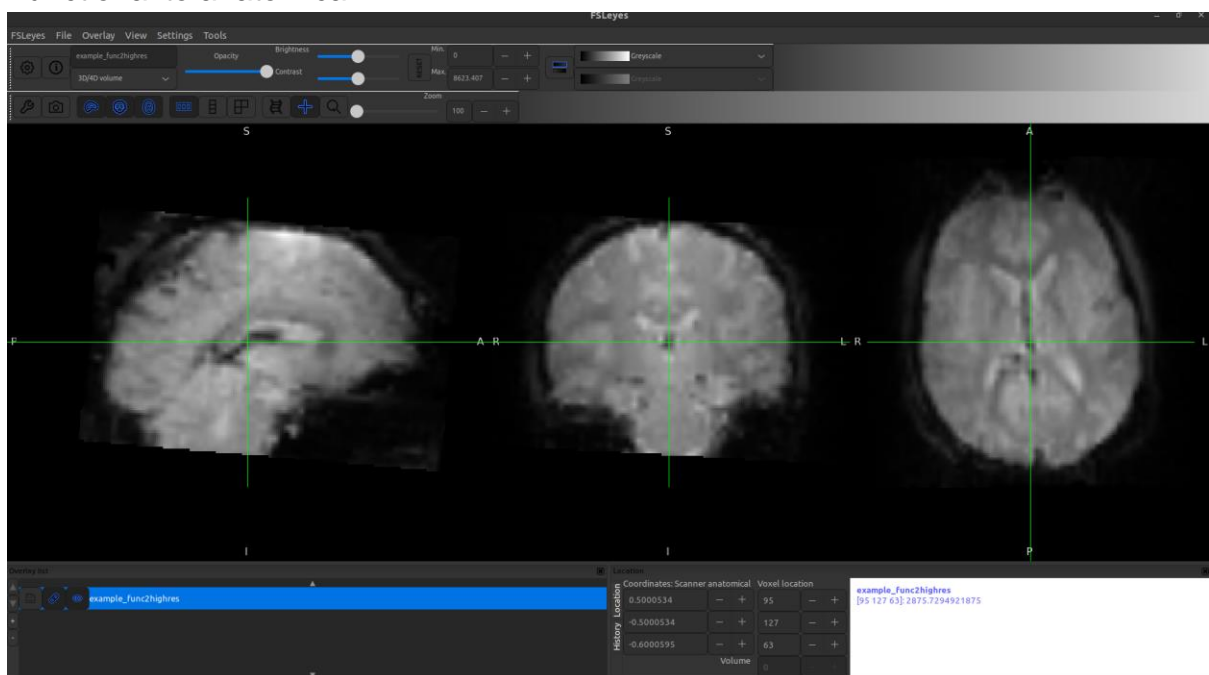


## Time series of motion corrected

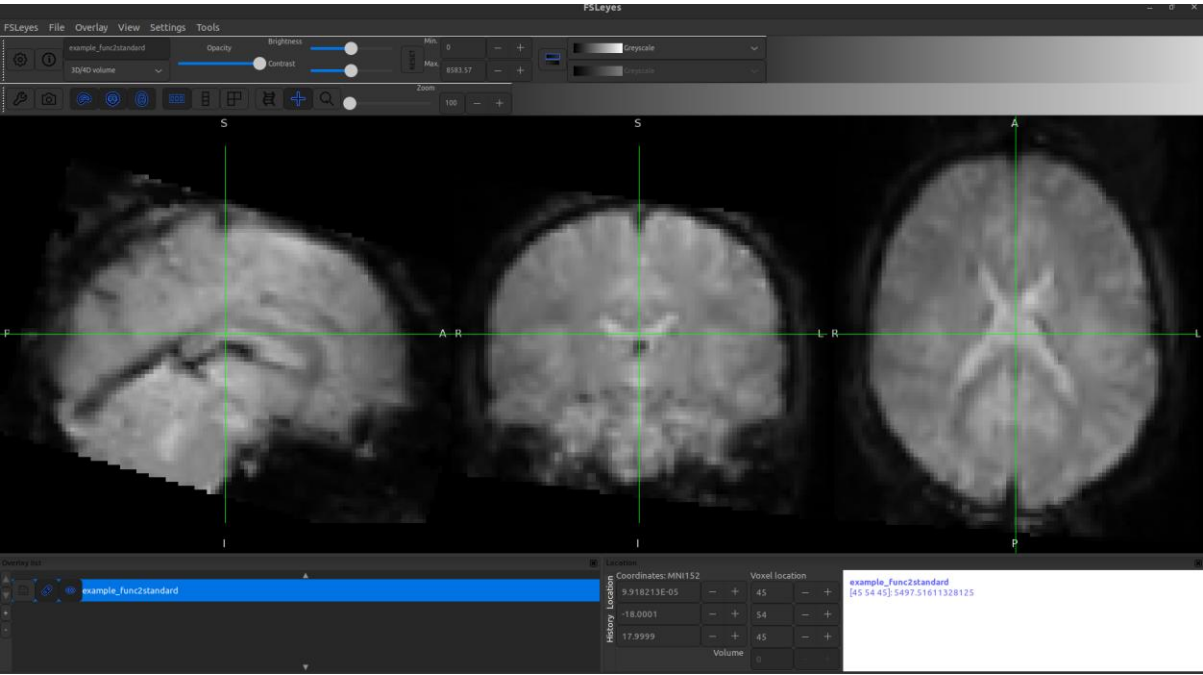


## Final registration

### Functional to anatomical

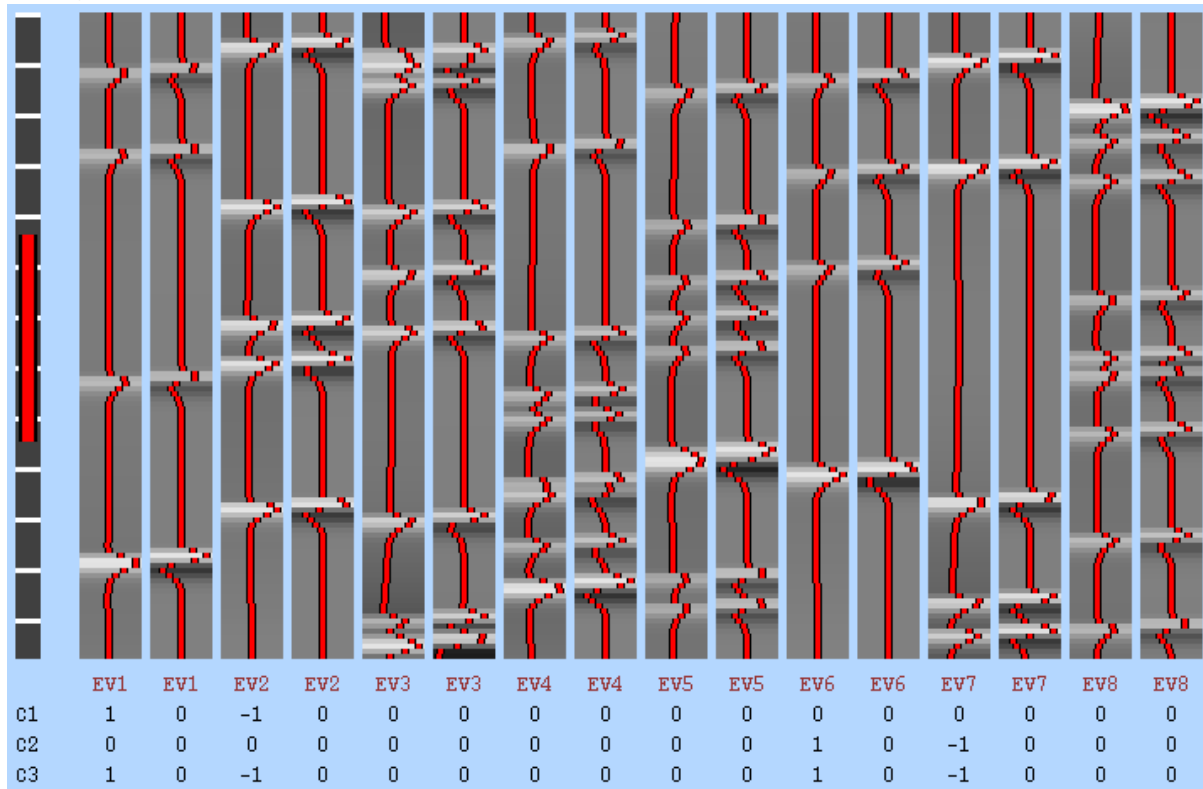


Functional to standard

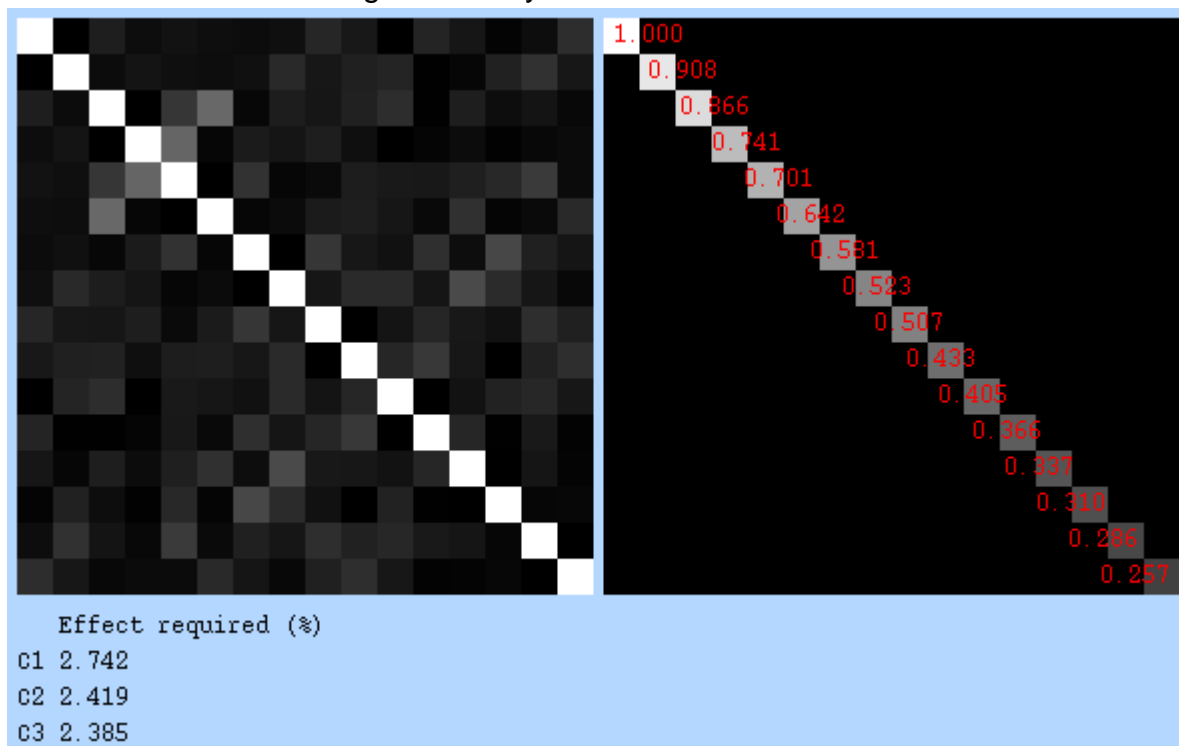


## Part 2

### Design matrix

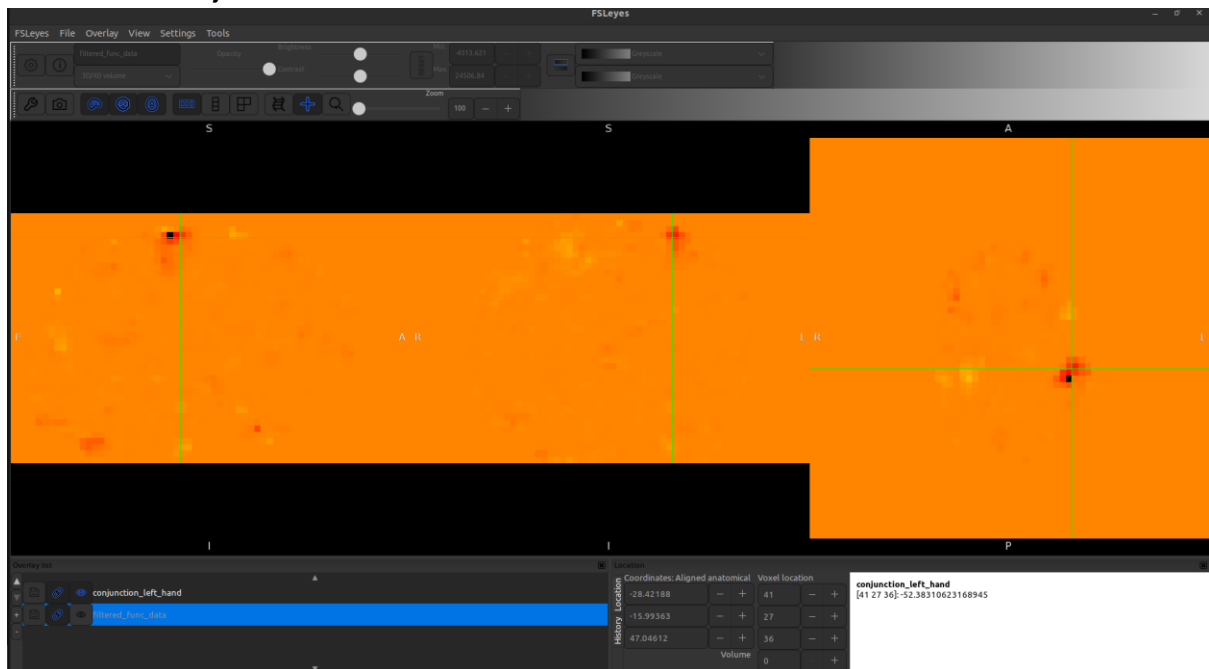


### Covariance matrix & design efficiency

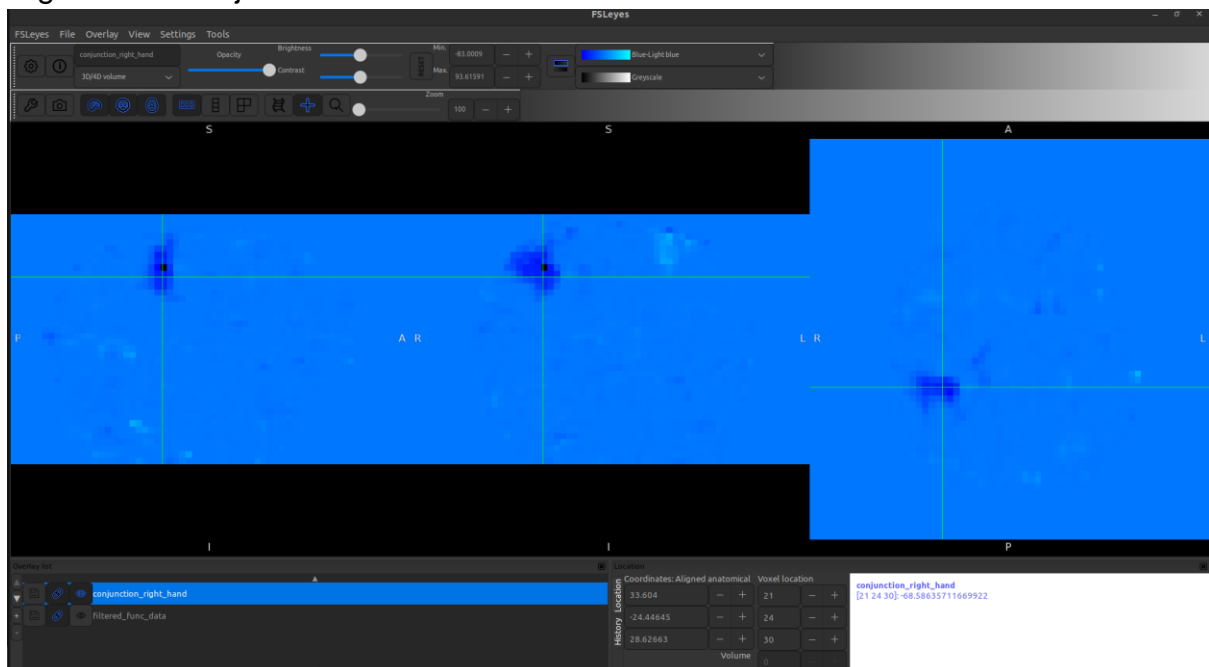




## Left Hand Conjunction

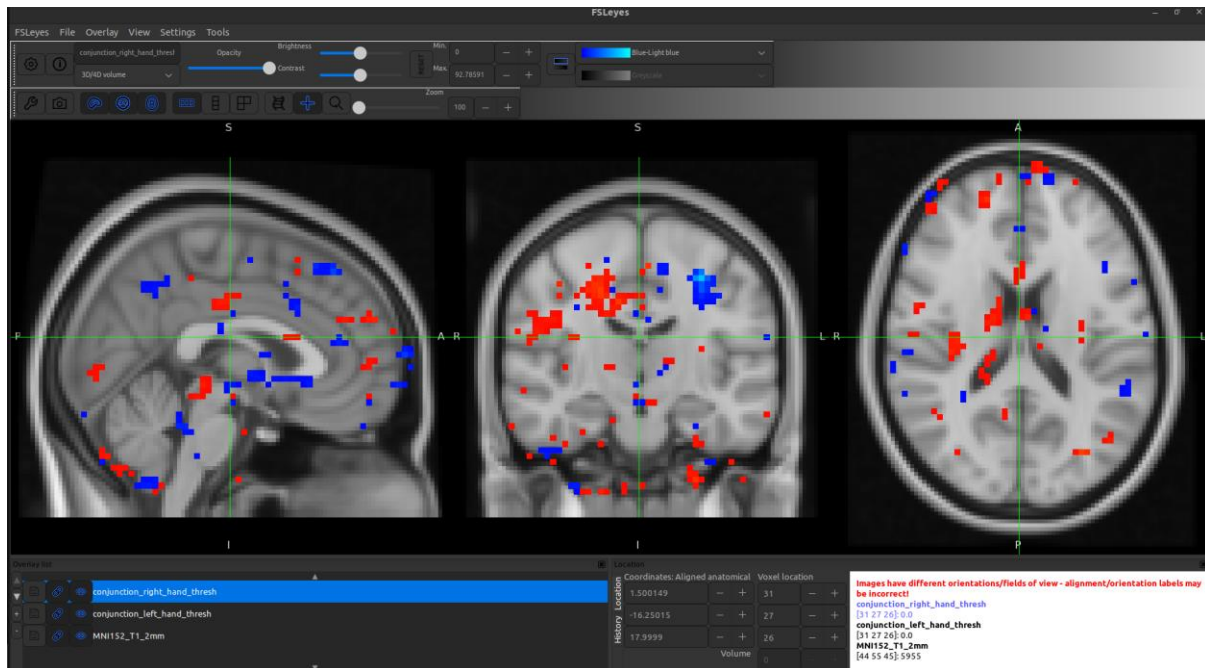


## Right Hand Conjunction



In Below image:

Brain areas selectively involved in left-hand movement (shown in red-yellow).  
Brain areas selectively involved in right-hand movement (shown in blue-lightblue).



The fMRI conjunction analysis findings reveal activation patterns for left-hand and right-hand movements overlaid on the MNI152 standard template. The red clusters correspond to left-hand movement activation, while the blue clusters represent right-hand movement activation. As per neurophysiological expectations, left-hand movement should primarily activate the right hemisphere, and right-hand movement should activate the left hemisphere due to contralateral motor control.

The observed results largely align with this ground truth, as activation is predominantly found in the expected hemispheres. However, some deviations are present, including minor ipsilateral activation—where certain regions in the same hemisphere as the movement exhibit activity—which is not typical for primary motor tasks. Additionally, bilateral activation is observed in certain areas, which may indicate involvement of secondary motor regions such as the Supplementary Motor Area (SMA) or could result from motion artifacts in the fMRI preprocessing pipeline. Furthermore, the expected cerebellar activation, which should be present contralaterally, is not clearly visible in the results. These deviations might stem from factors such as a lower statistical threshold, minor misalignments in functional-to-MNI registration, or preprocessing inconsistencies.

To refine the accuracy of the findings, increasing the Z-score threshold to filter out weak activations, verifying the quality of image registration, and reviewing preprocessing steps like motion correction and smoothing could be beneficial. Despite these minor discrepancies, the overall activation patterns are consistent with known motor control mechanisms in the brain.

## Deactivations

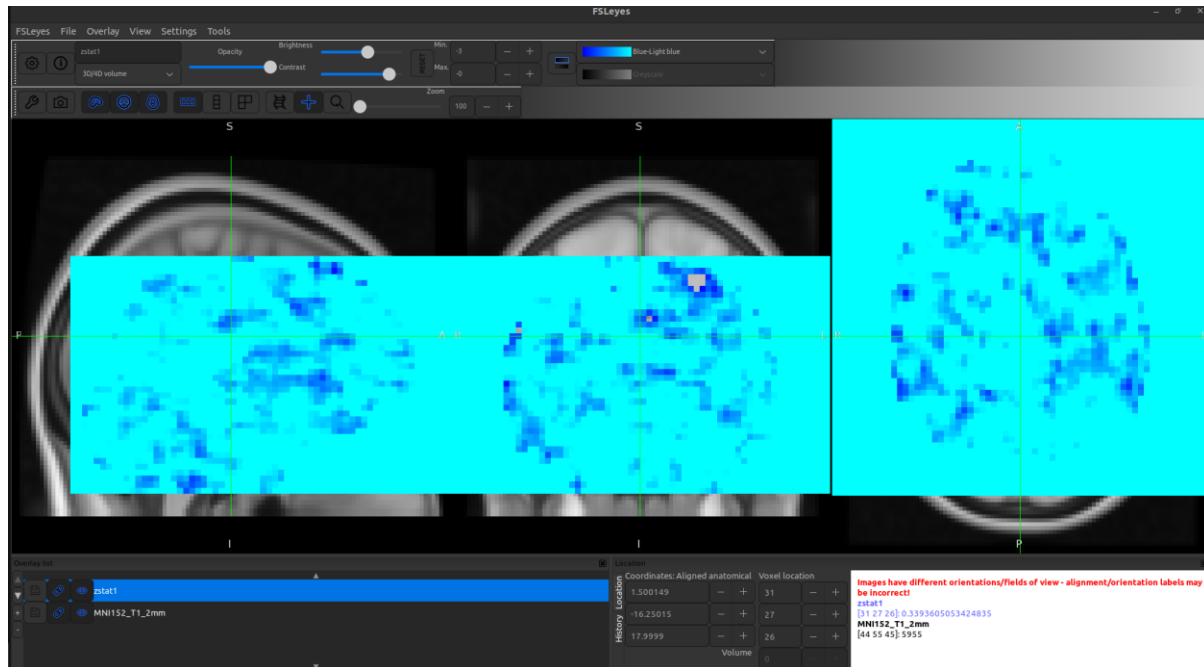


Table 01. Brain areas that are selectively involved in movement of the left hand (only those clusters included having size greater than 14).

Cluster's Size	MNI X (mm)	MNI Y (mm)	MNI Z (mm)	Brain's region
713	33	-24	33	No label found!
107	-57	-30	-36	1% Inferior Temporal Gyrus, posterior division
103	39	-51	-54	No label found!
52	-18	-6	-24	21% Parahippocampal Gyrus, anterior division
52	-33	-75	0	7% Lateral Occipital Cortex, inferior division, 3% Occipital Fusiform Gyrus
44	27	30	-15	67% Frontal Orbital Cortex, 20% Frontal Pole
41	3	-30	-6	No label found!
40	-33	-81	-24	9% Lateral Occipital Cortex, inferior division, 4% Occipital Fusiform Gyrus
38	48	27	-33	3% Temporal Pole
28	-6	57	6	62% Frontal Pole, 16% Paracingulate Gyrus, 4% Frontal Medial Cortex
27	21	-78	-6	38% Occipital Fusiform Gyrus, 12% Lingual Gyrus, 1% Lateral Occipital Cortex, inferior division
23	-45	3	-24	10% Temporal Pole, 8% Superior Temporal Gyrus, anterior division, 3% Planum Polare, 3% Middle Temporal Gyrus, anterior division
23	-9	-78	-3	43% Lingual Gyrus, 6% Occipital Fusiform Gyrus, 2% Intracalcarine Cortex

23	-27	-12	-54	No label found!
23	18	54	18	23% Frontal Pole
22	24	57	3	73% Frontal Pole
22	12	-81	3	46% Intracalcarine Cortex, 12% Lingual Gyrus, 1% Occipital Pole
21	-21	3	24	No label found!
20	-36	-21	-45	No label found!
20	15	54	-12	5% Frontal Pole
19	6	-72	-48	No label found!
18	48	3	33	47% Precentral Gyrus
18	6	-54	-60	No label found!
17	-27	9	48	31% Middle Frontal Gyrus, 9% Superior Frontal Gyrus
17	15	-69	-36	No label found!
17	-12	12	30	7% Cingulate Gyrus, anterior division, 1% Paracingulate Gyrus
17	36	33	-33	No label found!
16	9	-57	15	61% Precuneous Cortex, 11% Supracalcarine Cortex, 10% Intracalcarine Cortex
16	-21	-81	-15	59% Occipital Fusiform Gyrus, 9% Lingual Gyrus, 5% Lateral Occipital Cortex, inferior division
16	30	66	15	27% Frontal Pole
16	30	-18	-60	No label found!
15	15	3	-33	10% Parahippocampal Gyrus, anterior division

Table 02. Brain areas that are selectively involved in movement of the right hand (only those clusters included having size greater than 14).

Cluster's Size	MNI X	MNI Y	MNI Z	Brain's Region
252	-24	-57	-51	No label found!
168	-27	-21	48	5% Precentral Gyrus, 1% Postcentral Gyrus
134	30	-39	-9	22% Lingual Gyrus, 14% Parahippocampal Gyrus, posterior division, 2% Temporal Occipital Fusiform Cortex
126	66	-39	-3	37% Middle Temporal Gyrus, temporooccipital part, 30% Middle Temporal Gyrus, posterior division, 3% Superior Temporal Gyrus, posterior division, 1% Supramarginal Gyrus, posterior division
87	27	18	48	32% Middle Frontal Gyrus, 23% Superior Frontal Gyrus
79	0	27	-9	88% Subcallosal Cortex, 2% Paracingulate Gyrus, 1% Cingulate Gyrus, anterior division
70	-9	69	-6	62% Frontal Pole
67	0	36	51	31% Superior Frontal Gyrus
60	-6	-75	-45	No label found!
48	-3	9	42	43% Paracingulate Gyrus, 40% Cingulate Gyrus,

				anterior division, 8% Juxtapositional Lobule Cortex (formerly Supplementary Motor Cortex)
46	33	-39	-42	No label found!
45	60	9	21	45% Precentral Gyrus, 23% Inferior Frontal Gyrus, pars opercularis
44	-63	-42	-18	37% Inferior Temporal Gyrus, posterior division, 18% Inferior Temporal Gyrus, temporooccipital part, 18% Middle Temporal Gyrus, posterior division, 8% Middle Temporal Gyrus, temporooccipital part
30	18	-33	-3	9% Parahippocampal Gyrus, posterior division, 5% Cingulate Gyrus, posterior division, 2% Lingual Gyrus
29	-33	-54	33	6% Angular Gyrus, 4% Lateral Occipital Cortex, superior division, 4% Superior Parietal Lobule, 3% Supramarginal Gyrus, posterior division
27	39	3	-48	28% Inferior Temporal Gyrus, anterior division, 12% Temporal Pole, 11% Temporal Fusiform Cortex, anterior division, 3% Temporal Fusiform Cortex, posterior division, 1% Inferior Temporal Gyrus, posterior division
26	6	-54	42	85% Precuneous Cortex, 3% Cingulate Gyrus, posterior division
26	-33	-72	-45	No label found!
22	57	51	6	No label found!
22	-42	21	30	38% Middle Frontal Gyrus, 5% Inferior Frontal Gyrus, pars triangularis, 4% Inferior Frontal Gyrus, pars opercularis
21	42	36	-18	61% Frontal Pole, 21% Frontal Orbital Cortex, 1% Inferior Frontal Gyrus, pars triangularis
21	-33	24	9	57% Frontal Operculum Cortex, 7% Inferior Frontal Gyrus, pars triangularis, 4% Insular Cortex, 2% Frontal Orbital Cortex
20	-12	-69	30	43% Precuneous Cortex, 21% Cuneal Cortex, 2% Supracalcarine Cortex
20	9	-33	-39	No label found!
18	60	24	-18	No label found!
18	54	6	-45	4% Inferior Temporal Gyrus, anterior division, 3% Temporal Pole, 1% Middle Temporal Gyrus, anterior division
17	42	18	-21	67% Temporal Pole, 9% Frontal Orbital Cortex
17	-21	57	-6	61% Frontal Pole
16	48	-15	-42	29% Inferior Temporal Gyrus, posterior division, 8% Inferior Temporal Gyrus, anterior division, 3% Temporal Fusiform Cortex, posterior division, 1% Temporal Fusiform Cortex, anterior division
15	27	-60	33	20% Lateral Occipital Cortex, superior division, 2% Precuneous Cortex, 2% Angular Gyrus, 1% Cuneal Cortex
15	-24	-42	0	1% Lingual Gyrus, 1% Parahippocampal Gyrus, posterior division
15	45	57	15	2% Frontal Pole

## Part 3

### Method Used: A Combination of Subtraction & Conjunction Analysis

Reason to use it:

Subtraction Analysis helps isolate language-specific regions by comparing Language tasks (audio/video sentences) vs. non-language tasks (checkerboards, motor tasks). Conjunction Analysis finds brain areas active across multiple language tasks ensuring reliability.

Analysed two key explanatory variables (EVs) from fMRI data:

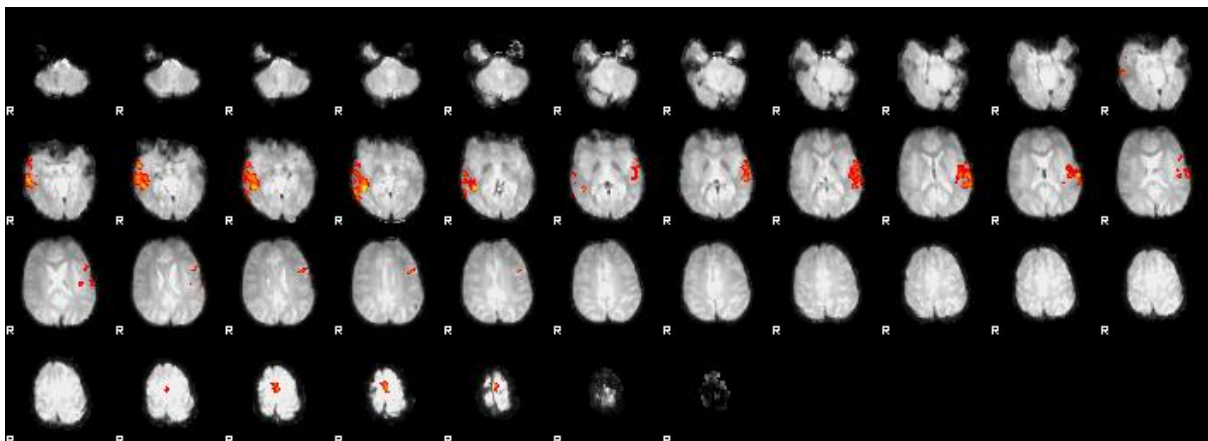
- Language Tasks:
  - *Audio Sentence*
  - *Video Sentence*
- Control Tasks (Non-Language):
  - *Horizontal Checkerboard*
  - *Vertical Checkerboard*

I created three contrasts to find language-specific activation:

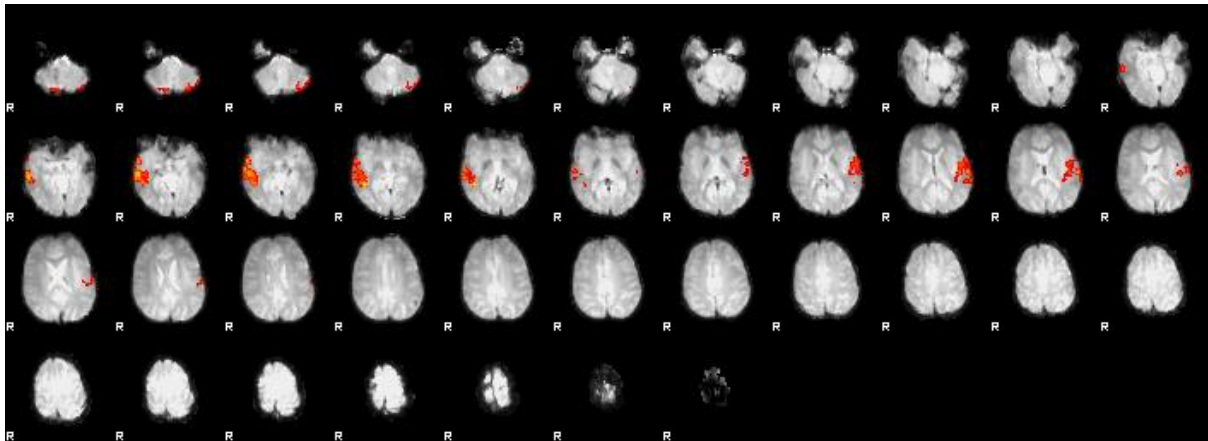
1. Language - Visual Control: identifies general language processing areas.
2. Audio Sentence - Checkerboard: isolates speech comprehension (auditory).
3. Video Sentence - Checkerboard: isolates speech perception (visual).

### Intermediate results

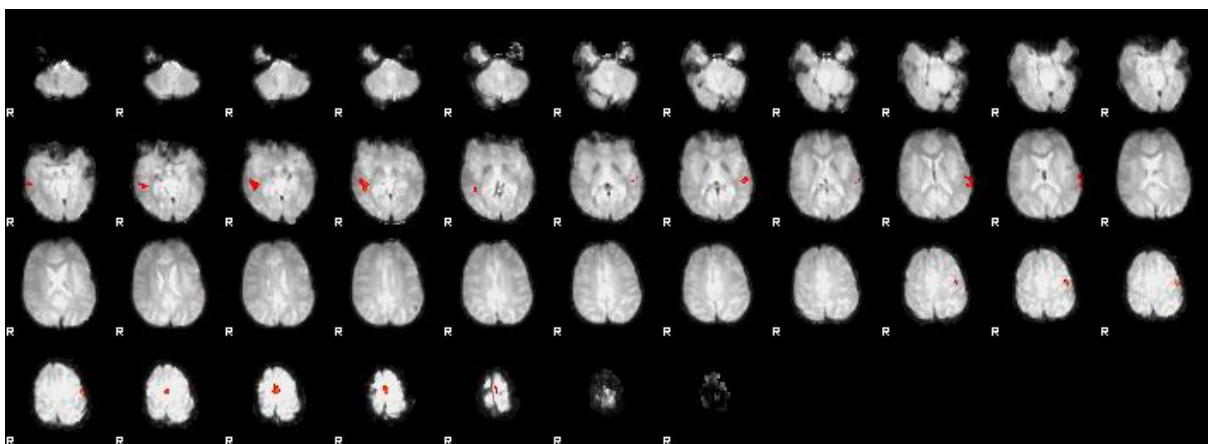
zstat1 - C1 (Language - Visual Control)



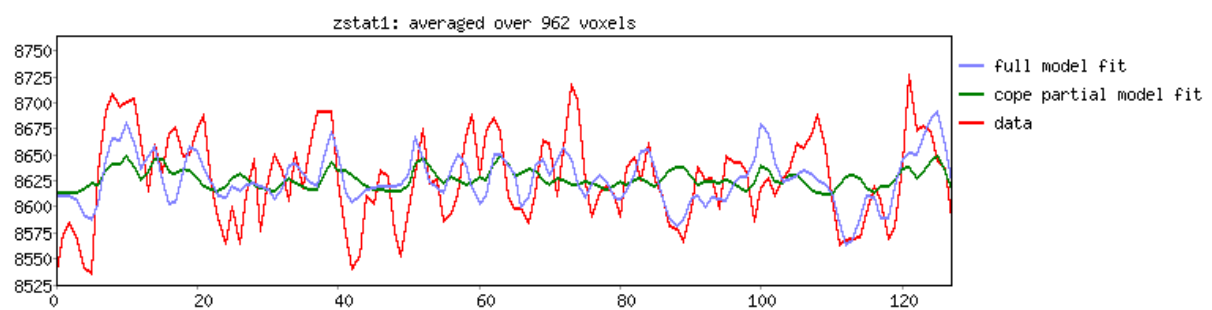
zstat2 - C2 (Audio Sentence - Checkerboard)



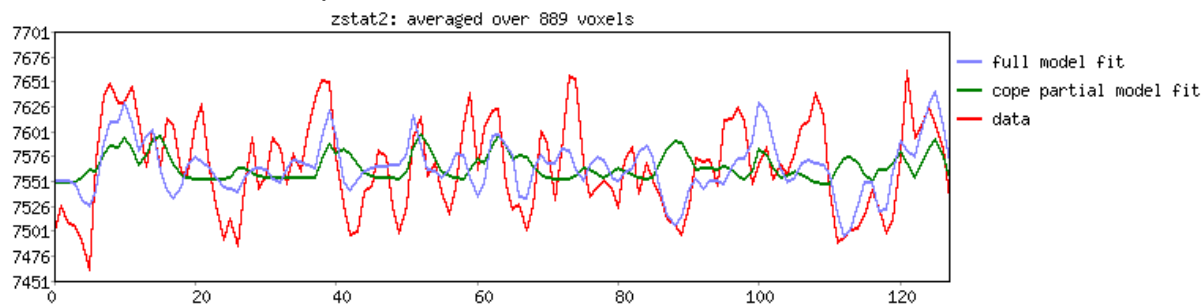
zstat3 - C3 (Video Sentence - Checkerboard)



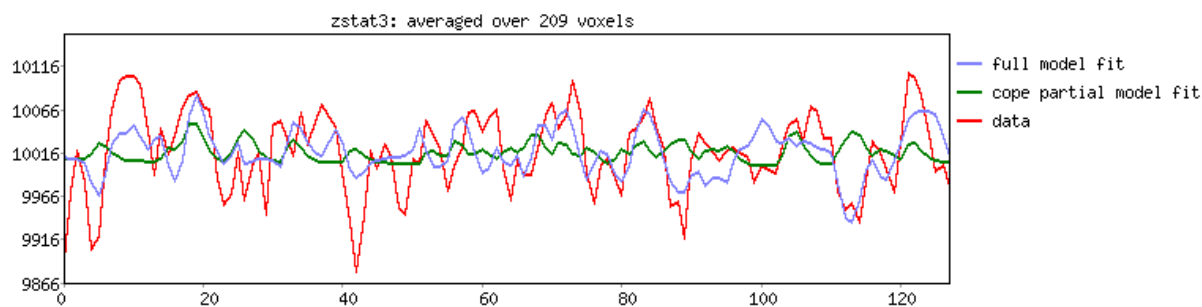
FEAT Time Series Report - zstat1



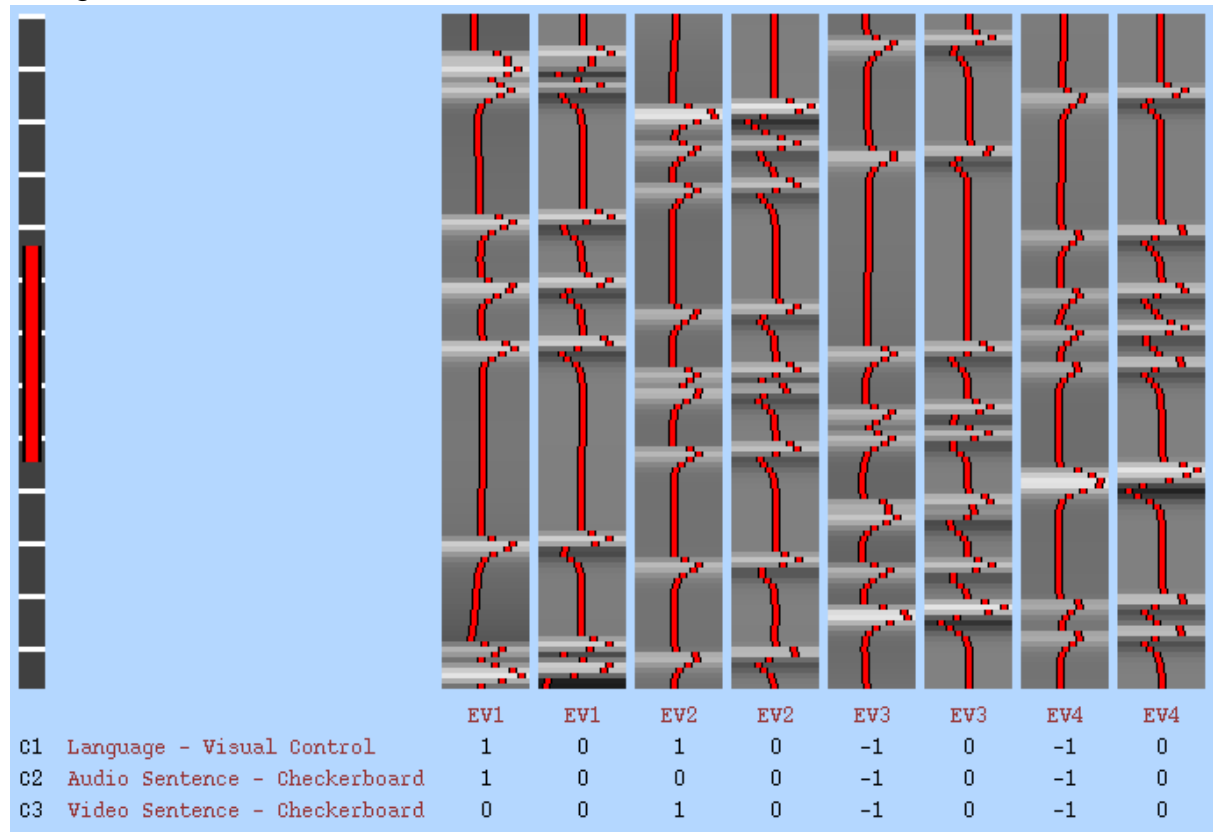
FEAT Time Series Report - zstat1



FEAT Time Series Report - zstat1

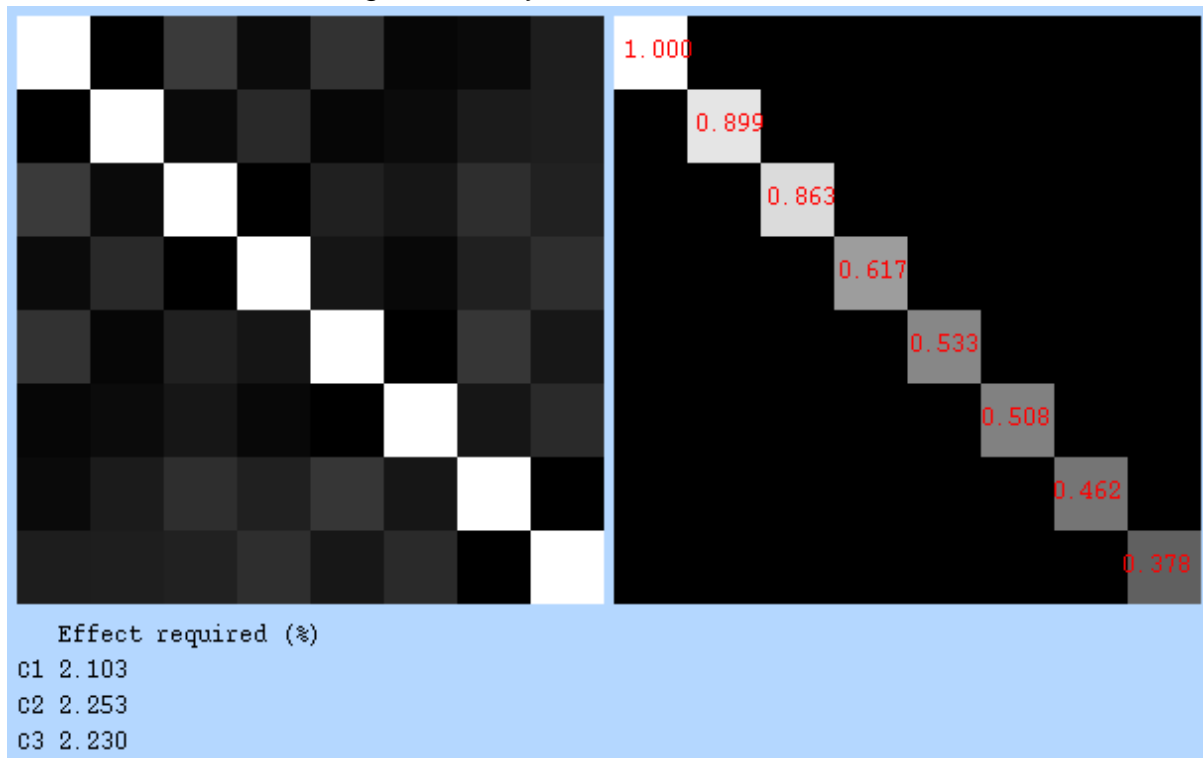


Design Matrix

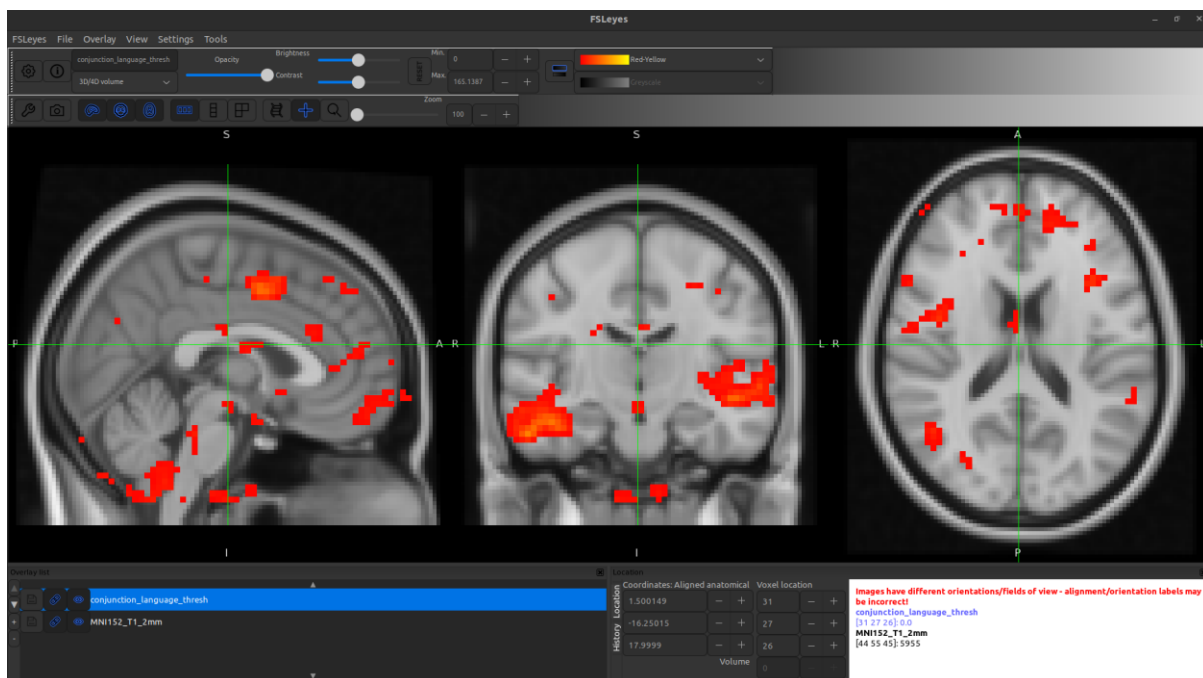




## Covariance matrix & design efficiency



## Final Result



My thought on this finding:

The activation in the left inferior frontal gyrus (LIFG) aligns with Broca's area, supporting its role in speech production and language comprehension. Similarly, left superior temporal gyrus (STG) activation matches Wernicke's area, crucial for

understanding spoken language. Some activation in the right hemisphere, particularly in frontal and temporal regions, is expected for higher-order language processing.

Table 03. Indicating clusters involved in language comprehension (only those clusters included having size greater than 9).

Cluster's size	MNI X	MNI Y	MNI Z	Brain's Region
2022	-63	-21	-3	58% Superior Temporal Gyrus, posterior division, 26% Middle Temporal Gyrus, posterior division, 2% Planum Temporale, 1% Heschl's Gyrus (includes H1 and H2), 1% Middle Temporal Gyrus, anterior division
1815	42	-30	-18	27% Temporal Fusiform Cortex, posterior division, 23% Inferior Temporal Gyrus, posterior division, 4% Inferior Temporal Gyrus, temporooccipital part, 1% Temporal Occipital Fusiform Cortex
1110	9	-66	-57	No label found!
392	3	0	45	64% Cingulate Gyrus, anterior division, 22% Juxtapositional Lobule Cortex (formerly Supplementary Motor Cortex), 1% Cingulate Gyrus, posterior division
94	45	21	0	43% Frontal Operculum Cortex, 12% Frontal Orbital Cortex, 12% Inferior Frontal Gyrus, pars triangularis, 3% Inferior Frontal Gyrus, pars opercularis, 2% Insular Cortex
80	18	-87	-33	No label found!
80	24	42	-3	1% Frontal Pole
66	-12	-84	-36	No label found!
66	9	42	48	42% Frontal Pole, 14% Superior Frontal Gyrus
62	-39	-3	39	18% Precentral Gyrus, 5% Middle Frontal Gyrus
56	15	-36	3	3% Cingulate Gyrus, posterior division
41	-27	-12	48	22% Precentral Gyrus, 4% Middle Frontal Gyrus, 1% Superior Frontal Gyrus
38	42	-3	18	32% Central Opercular Cortex
34	-39	15	-27	62% Temporal Pole
30	-3	-18	27	40% Cingulate Gyrus, posterior division, 17% Cingulate Gyrus, anterior division
28	6	27	24	57% Cingulate Gyrus, anterior division, 3% Paracingulate Gyrus
26	3	-33	-27	No label found!
24	-9	-63	42	43% Precuneous Cortex
22	18	-36	48	11% Postcentral Gyrus, 3% Precentral Gyrus, 1% Precuneous Cortex, 1% Cingulate Gyrus, posterior division
22	-45	-69	9	64% Lateral Occipital Cortex, inferior division, 6% Lateral Occipital Cortex, superior division
20	33	-36	45	25% Postcentral Gyrus, 22% Superior Parietal Lobule, 12% Supramarginal Gyrus, posterior division, 6% Supramarginal Gyrus, anterior division
20	30	57	30	26% Frontal Pole
20	-12	-39	12	1% Cingulate Gyrus, posterior division

17	6	0	-21	1% Parahippocampal Gyrus, anterior division
15	9	-75	24	41% Cuneal Cortex, 8% Supracalcarine Cortex, 5% Precuneous Cortex
14	-60	18	-27	No label found!
13	0	-33	54	22% Precentral Gyrus, 8% Postcentral Gyrus, 4% Precuneous Cortex, 1% Cingulate Gyrus, posterior division
13	-39	-18	-24	51% Temporal Fusiform Cortex, posterior division, 12% Parahippocampal Gyrus, anterior division, 5% Temporal Fusiform Cortex, anterior division, 3% Inferior Temporal Gyrus, posterior division
13	-3	-75	-15	2% Lingual Gyrus
12	-21	12	51	39% Superior Frontal Gyrus, 10% Middle Frontal Gyrus
12	18	36	21	1% Paracingulate Gyrus
11	9	12	-6	No label found!
10	15	66	24	58% Frontal Pole